REMARKS

Claims 1-19 remain in the application with claim 1 amended to more particularly define the invention and further distinguish the cited prior art.

The Examiner has indicated that claims 5-13 would be allowable if rewritten in independent form including all limitations of the base claim and intervening claims.

Reconsideration is respectfully requested for claims 1-4 and 14-19 as amended.

Claims 1-4 and 14-19 have been rejected under 35 USC §102(b) as being anticipated by Glover et al. 5,225,781, the Examiner alleging that Glover et al. anticipate all claimed features of claims 1-3 and 14-16.

This rejection is respectfully traversed with respect to claims 1-4 and 14-19 as amended. The invention is related to separation of fat and water through "in phase" and "out of phase" imaging as first demonstrated by Dixon and as further refined by Glover et al., all as noted in paragraph [0005] of the Background of the Invention. However, as further noted, application of "Dixon" imaging to fast spin echo (FSE) sequences has been limited because of the acquisition echoes at different time shifts with respect to the spin echo increases the spacing between successive refocusing pulses or echo spacing. Increasing the echo spacing reduces the number of echoes that can be collected in a time that maintains acceptable blurring from signal decay.

As noted in the Summary of the Invention, paragraph [0007], the claimed invention utilizes a multi-point chemical species separation process which is compatible with a rapid gradient echo imaging technique, such as steady state free precession (SSFP), fast spin echo, echo planar imaging, spin echo, spiral imaging, and other similar pulse sequences. As further noted, an iterative least squares fitting algorithm is utilized to combine signals at different echo times using an assumed initial value of field heterogeneity.

The invention is further described in paragraph [0020] where an iterative linear least squares approach is formulated and a generalized algorithm with arbitrary echo times and multiple chemical species is described. Equation (2) sets forth the measured signals which contains M complex unknowns for M species and one scaler unknown.

As further described in equation (3), if an initial estimate of the field map is known, then a linear system of complex equations can be split into real and imaginary ports from which chemical species can be decomposed using a least squares fitting of the measured signals.

This is now more specifically defined in claim 1 as amended in which a method of obtaining magnetic resonance signals with signal separation for at least two chemical species in a heterogeneous magnetic field using rapid gradient echo imaging comprises the steps of a) obtaining first magnetic resonance signals from pixels, b) obtaining at least second and third magnetic resonant signals from the pixels, and c) determining a signal estimate for each species and for each pixel by combining all signals for the pixel using a linear least squares fitting of the signals from each pixel to decompose the chemical species.

The equation for the signals and the least squares fitting are given in claim 4, the known matrix A for M species is given in claim 5, and the error in field heterogeneity is given in claim 6.

Thus, the claimed invention uses the least squares estimation for the water and fat signals, given the pixel images at different echo times. The use of least squares estimation is a "maximum likelihood estimator" that gives the best noise performance of the water-fat decomposition.

The cited Glover et al. patent is related to water and fat separation, but Glover et al. use a least squares method to resolve ambiguities in phase where a measured phase can "wrap around" for phase angles greater than $\pi/2$. Thus, Glover et al. are trying to remove ambiguity in the actual phase where the measured phase can have "wrap around". Note the description of resolving ambiguities in phase in columns 11 and 12 of the Glover et al. patent for a polynomial equation (25) which is fit to the derivative of the measured phase, ϕm, using a weighted least squares method in the phase curve fitting.

"Least-squares fitting" is a known mathematical procedure which Glover applied to one estimation problem (phase unwrapping) while Applicants apply the procedure to completely different and unrelated estimation problems (iterative estimation of a field map and estimation of signals from different chemical species).

Thus, unlike the claimed method where a linear least squares fitting of signals is used to decompose chemical species signals, Glover et al. use a weighted least squares method in determining phase of signals and phase unwrapping using polynomials in describing the phase. The phase correction described by Glover et al. has nothing to do with combining of signals using a least squares fitting of signals.

Since claims 5-13 are indicated to be allowable, and since claims 1-4 and 15-19 as amended are patentable under 35 USC §102(b) and §103 over Glover et al., all as above set forth, it is requested that claims 1-4 and 14-19 as amended be allowed along with claims 5-13 and the case advanced to issue.

Should the Examiner have any question or comment concerning the present amendment and response, a telephone call to the undersigned attorney is requested.

Respectfully submitted,
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